IS 12022 (1987): Method of Testing Quality Characteristics of Piston Rings [TED 2: Automotive Primemovers]

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*Indian Standard*

# METHOD OF TESTING QUALITY CHARACTERISTICS OF PISTON RINGS

Automotive Primemovers Sectional Committee, EDC 102; Piston Assembly Components Subcommittee, EDC 102 : 1 [Ref : Doc : EDC 14 (3362)]

**1. Scope** — Covers the recommended practice for dimensional measurements and load characteristics of piston rings used in internal combustion engines.

**2. Nomenclature** — Nomenclature shall be according to IS : 5791-1986 'Technical supply conditions for piston rings for IC engines (*second revision*)' (*see* Fig. 1).

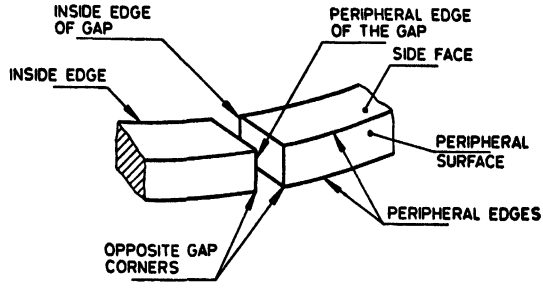


FIG. 1 NOMENCLATURE

**3. Quality Characteristics and Recommended Measuring System**

**3.1** *Piston Ring Outer Diameter $d_1$ and closed gap $s_1$*

**3.1.1** Outer diameter $d_1$ of a piston ring is equal to the nominal cylinder bore in which the ring is to be fitted.

**3.1.2** The diameter shall be checked by placing the ring squarely in a control gauge having a diameter equal to the nominal bore diameter $\pm 2$ percent of the tolerance on closed gap dimensions and measuring the closed gap $s_1$ to be within specified limits as shown in Fig. 2.

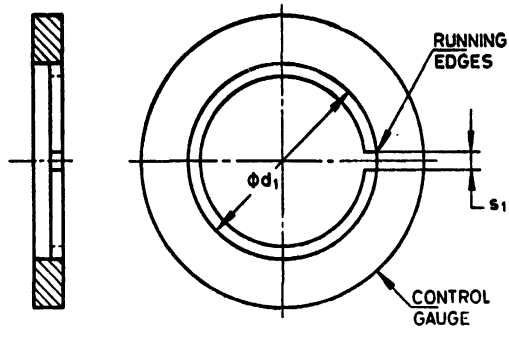


FIG. 2 MEASUREMENT OF PISTON RING OUTER DIAMETER

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3.2 *Closed Gap* ($s_1$)

3.2.1 The closed gap is the distance between the gap ends when the ring is closed to nominal diameter. It is to be measured at the narrowest point of gap which, in case of normal manufacturing process, occurs at running edge.

3.2.2 The closed gap may be measured with limit gauges (feeler gauges) when the ring is held squarely in closed condition in a precise circular control gauge having a diameter equal to the nominal bore diameter.

3.3 *Axial Width* ($h_1$)

3.3.1 Distance between flanks at random points measured parallel to the ring axis.

3.3.2 The axial width shall be measured by placing the ring on a ground plate on which a U-type fixture freely oscillates about a fulcrum, the top end of the fixture carries a dial indicator with least count of 0·001 mm, having a spherical ball at the end and an adjustable spherical ball mounted on the other end below the plate ( Fig. 3 ). Both the dial indicator ball and lower ball of 3 mm diameter meet at a point through a hole in the plate. The axial width is then measured after setting the distance between the dial indicator ball and lower ball with a precision slip gauge of the required dimensions. The measuring force on the dial indicator shall be 1N approximately.

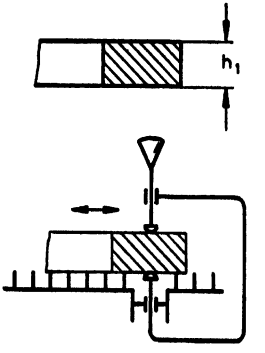



FIG. 3 MEASUREMENT OF AXIAL WIDTH

3.3.3 For slotted oil control rings, measurement has to be made between the slots and not across the slots.

3.4 *Radial Wall Thickness* ($a_1$)

3.4.1 Radial distance between running (outer) face and inner face of the ring.

3.4.2 The radial wall thickness may be measured with a micrometer having a spherical anvil contacting on the inner face of the ring and flat surface of the micrometer spindle on the outer surface ( radius of envil shall be 4 mm ) as shown in Fig. 4.

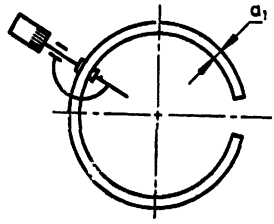
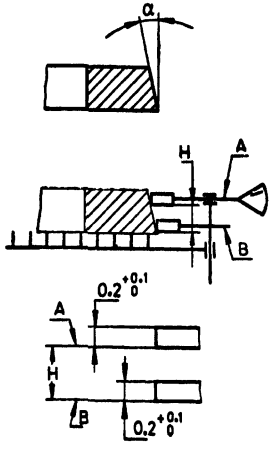



FIG. 4 MEASUREMENT OF RADIAL WALL THICKNESS

**3.5** *Taper on Running Face*

**3.5.1** Taper on the running face or conicity is the deviation of the form of running face from the specified true cylindrical form.

**3.5.2** The taper on the running face shall be measured in the axial direction of the ring in a free state at right angles to the datum surface. The ring is placed on a fine ground plate. The running face of the ring makes contact with two edges (width of each edge being 0·2 mm) having a known axial distance *H* between them. The upper edge is floating and has contact with the dial indicator having a least count of 0·001 mm while the lower edge is fixed. Deflection of dial indicator is noted for calculating the value of tangent for finding out the angle or conicity in minutes. Distance *H* between the two edges depends upon the axial height of the rings and is given in table with Fig. 5. The dial indicator is set at zero with a ground cylindrical reference piece.




| $h_1$ | *H* |
|---|---|
| 1·5 | 0·8 |
| 1·75 | 1·0 |
| 2·0 | 1·5 |
| 2·5 | 2·0 |
| 3·0 | 2·5 |
| 4·0 | 3·0 |
| 5·0 | 3·5 |
| 6·0 | 4·0 |

FIG. 5 MEASUREMENT OF TAPER ON RUNNING FACE

**3.6** *Trapezoidal Width* ($h_1$)

**3.6.1** Axial width of the trapezoidal ring measured as the distance between two corresponding points on the side faces in the axial direction at 1·5 mm from the running face.

**3.6.2** The trapezoidal axial width shall be measured as shown in Fig. 6, using a dial indicator with least count of 0·001 mm with a sharp, hard conical point at one end and adjustable conical point at the other end below the plate: An adjustable stopper is provided to enable the checking at a distance of 1·5 mm from the running face of the ring. The setting of the dial indicator is done by placing precision slip gauges of the required sizes between both the conical points. The load on the dial comparator shall be 1N approximately.

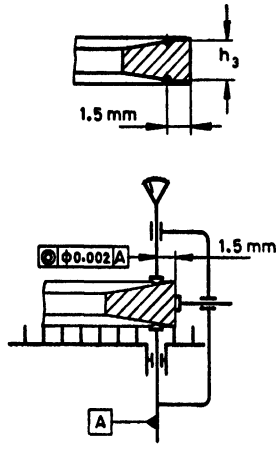



FIG. 6 MEASUREMENT OF TRAPEZOIDAL WIDTH

**3.6.3** Alternatively, trapezoidal axial width may be measured using a gauge constructed as shown in Fig. 7. The width shall be calibrated using a master ring gauge whose width is independently calibrated by any suitable method.

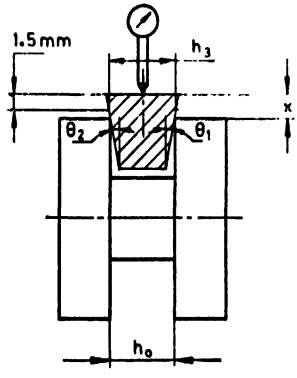



FIG. 7 MEASUREMENT OF TRAPEZOIDAL WIDTH ALTERNATIVE

**3.7** *Trapezoidal Angle*

**3.7.1** It is the included angle between the two sides ( flanks ) of the ring.

**3.7.1.1** The angle shall be measured in axial section of the ring as the sum of the two side face angles. The angle shall be measured with an optical protractor.

**3.7.1.2** The correctness and symmetry of the angles on both the side faces shall be verified by reading the deflection of two probes on the same side at a fixed distance apart and by calculating the tangent value. While checking, the ring shall be placed in such a way that the alignment of the two gauges is with the centre of the ring ( Fig. 8 ).

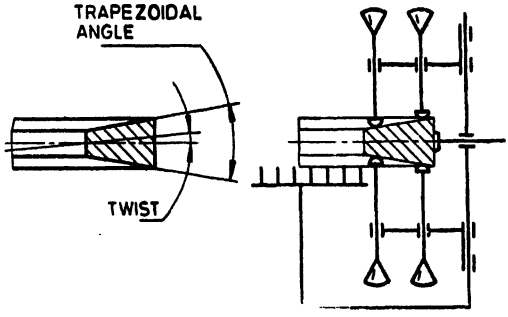



FIG. 8 MEASUREMENT OF TRAPEZOIDAL ANGLE

**3.7.1.3** Alternatively, the included angle of the trapezoidal ring may be checked using a gauge constructed as shown in Fig. 9.

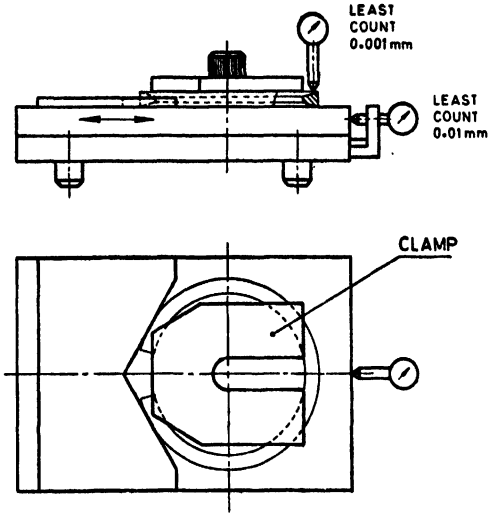



FIG. 9 MEASUREMENT OF TRAPEZOIDAL ANGLE ( Alternative )

**3.8** *Chromium Layer Thickness*

**3.8.1** The layer thickness is the distance between the surface of the coating and the basic ring material ( Fig. 10 ).

**3.8.2** Non-destructive testing, using magnetic-inductive instrument, shall be made in the middle of width $h_1$ for chromium plated compression rings and is taken at three points, that is, at the back of the ring, and at 15 mm from each gap end at a point opposite the gap.

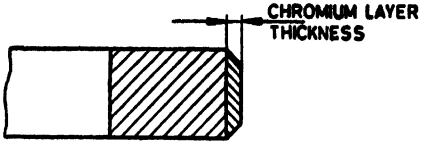



FIG. 10 MEASUREMENT OF CHROMIUM LAYER THICKNESS

3.8.3 The outer edges of the ring for chromium plating have to be chamfered or rounded adequately so that the chromium layer smoothly blends with flanks of the ring without leaving any sharp edges or flaking of the layer at the edges ( Fig. 11 ).

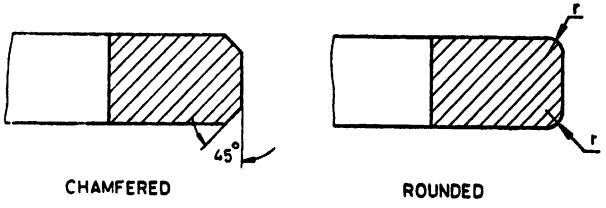



FIG. 11 OUTER EDGE DETAILS MEASUREMENT

3.8.4 The chamfering shall be measured with the help of graduated reading eye-glass of magnification 10 X and least count of 0·1 mm.

3.9 *Crowning* ($t_s$), ($t_s$)

3.9.1 Crowning is the specific barrel-forming deviation of the profile of the running face from the cylindrical form ( Fig. 12 ).

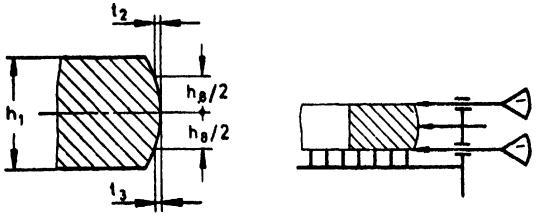



FIG. 12 MEASUREMENT OF CROWNING

3.9.2 The crowning may be determined by magnification using a shadow graph or by any other suitable contour checking instruments.

3.9.3 Crowning shall be determined at a distance $h_s/2$ from the ring centre as given in Table 1.

TABLE 1 DETAILS FOR MEASURING CROWNING

All dimensions in millimetres.

| Ring Height | Measuring Height | Crowning | |
|---|---|---|---|
| $h_1$ | $h_s$ | $t_2$ | $t_3$ |
| 1·5 | 0·8 | | |
| 2·0 | 1·2 | 0·003 to 0·012 | 0·003 to 0·012 |
| 2·5 | 1·6 | | |
| 3·0 | 2·0 | | |
| 3·5 | 2·4 | 0·005 to 0·016 | 0·005 to 0·016 |
| 4·0 | 2·8 | | |
| 4·5 | 3·2 | | |

**3.10** ***Edge Breaking (Outer Edges KA) and ( Inner Edges KI )***

**3.10.1** The outer and inner edges of the ring may be chamfered at 45° in certain cases where the design calls for such edge-breaking ( Fig. 13 ).

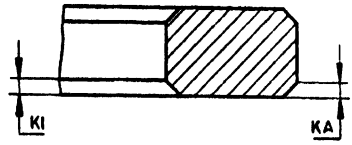
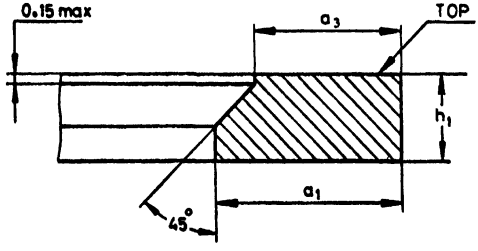



FIG. 13 EDGE BREAKING ( CHAMFERING )

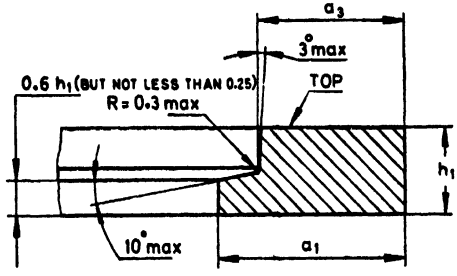
**3.10.2** The edge breaking (chamfering) shall be measured with the help of a graduated reading eye-glass of magnification 10X and least count 0·1 mm.

**3.11** ***Counterboring: Inner Edge Bevelling ( IF ) and Inner Step ( IW )***

**3.11.1** Counterboring is provided on upper inner edge of a ring towards piston crown in order to obtain a slight conicity on the running face when the ring is closed causing the lower edge of running face to form an effective sealing edge for good seating in and better oil control ( Fig. 14).




IF RING




IW RING

| Nominal Dia mm | $a_3$ | |
|---|---|---|
| | | Tolerance |
| 30 — 80 | $0{\cdot}8\ a_1$ rounded off to nearest 0·1 mm | − 0·2 − 0·0 |
| 80 — 174 | | − 0·3 − 0·0 |
| > 175 | | − 0·4 − 0·0 |

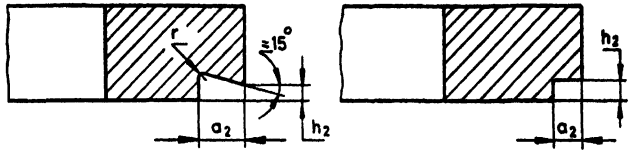
FIG. 14 MEASUREMENT OF COUNTERBORING

3.11.2 The dimension of inner edge bevelling shall be measured with a graduated reading eye-glass of magnification 10X and least count 0·1 mm. The dimension of counter boring shall be measured with a knife edge vernier caliper with provision for depth measurement.

3.12 *Outside Nose and Step of N-Ring and Z-Ring*

3.12.1 Nose/step is provided on the lower edge of running face of the ring for better oil-scraping effect.

3.12.2 Dimensions $h_2$ and $a_2$ of napier and step ring shall be measured with a graduated reading eye-glass of magnification 10X and least count 0·1 mm (Fig. 15).




N-Ring Z-Ring

FIG. 15 MEASUREMENT OF NOSE AND STEP

3.13 *Land Width $h_4$ and $h_5$*

3.13.1 Land width in case of slotted oil ring is half the width of each running face which makes a contact with the cylinder wall.

3.13.2 The land width $h_4$ shall be measured with graduated reading eye-glass of magnification 10X and least count 0·1 mm. For rapid determination of variation between the two lands, an instrument having an included angle of 53° is placed on each land in such a manner that both the edges of the land touch the angular surfaces symmetrically and difference in reading of the dial indicator having least count of 0·01 mm against the running face of each land gives the difference in the widths of the two lands (Fig. 16).

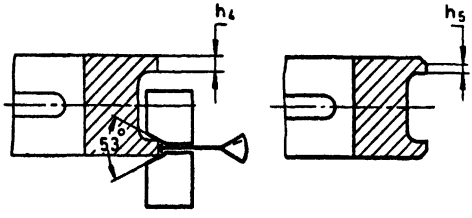



FIG. 16 MEASUREMENT OF LAND WIDTH

3.13.3 For more accurate measurements microscopes may also be used.

3.14 *Groove Depth $A_4$*

3.14.1 Groove depth is the distance between the running face of the lands and the bottom of the groove ( Fig. 17 ).

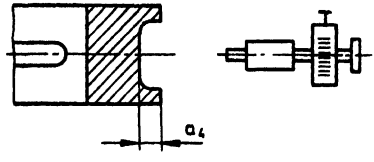



FIG. 17 MEASUREMENT OF GROOVE DEPTH

**3.14.2** The groove depth shall be measured with a depth micrometer of least count 0·01 mm.

**3.15** *Slot Width* $C_1$

**3.15.1** Slot width in the slotted oil ring depends upon the axial width $h_1$ of the rings. The slots are provided in the centre of axial width of the rings to facilitate drainage of oil ( Fig. 18 ).

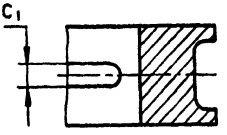



FIG. 18 MEASUREMENT OF SLOT WIDTH

**3.15.2** The slot width shall be measured with a feeler gauge.

**3.16** *Slot Distribution* $W_1$, $W_2$

**3.16.1** Slot distribution is preferably 1 : 1 ( slot length : bridge lengths; $W_1$ and $W_2$ respectively) ( Fig. 19 ).

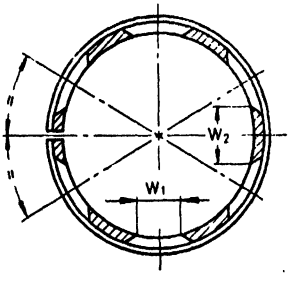



FIG. 19 MEASUREMENT OF SLOT DISTRIBUTION

**3.16.2** Slot length and bridge length shall be measured with either vernier calipers or with spiral strip-width gauges.

**3.16.3** The permissible difference between $W_1$ and $W_2$ is :

For rings up to 170 mm dia : 2 mm

For rings above 170 mm dia : 4 mm

**3.17** *Light Leakage or Light Tightness*

**3.17.1** It is the light tight fit of the piston ring against the cylinder wall. The leakage of light shall be measured according to 9.3 of IS : 5791-1986 ( *see* Fig. 20 ). The test fixture bore shall be precision machined to nominal cylinder bore diameter ±0·001 mm. The permissible tolerance for nominal diameter is ±0·001 $d_1$ while the permissible out of roundness shall be 0·0001 $d_1$. ( *see* 3.1 )

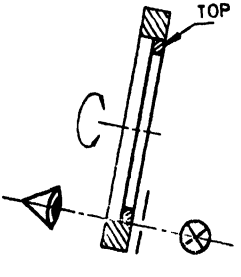



FIG. 20 LIGHT LEAKAGE TEST

3.18 *Tangential Force* ( $F_t$ )

3.18.1 The tangential force is the force which is necessary to close the ring to the required closed-gap with load applied tangentially at gap ends.

3.18.2 For measuring the tangential force, a special apparatus shall be used where a flexible steel band is put round the ring and force is applied tangentially at gap-ends to close the ring to specified closed-gap $s_1$ and taking readings in Newtons.

The principle of applying the force is shown in Fig. 21.

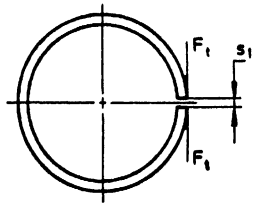



FIG. 21 MEASUREMENT OF TANGENTIAL FORCE

3.19 *Diametral Force* ( $F_{ds}$ *and* $F_{dd}$ )

3.19.1 a) The diametral force ( $F_{ds}$ ) is the force necessary to close the ring to specified closed-gap $s_1$ applied diametrically at 90° to the axis through the gap ends.

b) The diametral force ( $F_{dd}$ ) is the force necessary to close the ring to the specified nominal diameter $d_1$ applied diametrically at 90° to the axis through the gap ends.

3.19.2 For measuring the diametral force, special apparatus shall be used where the magnitude of force, applied along the diameter of the ring at 90° to the axis passing through the gap, closing the ring to the specified closed gap ( $F_{ds}$ ) or to the specified nominal ring diameter $d_1$ ( $F_{dd}$ ) as the case may be, shall be directly measured ( Fig. 22 ).

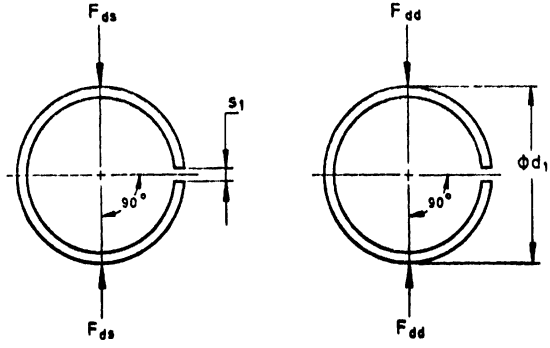



FIG. 22 MEASUREMENT OF DIAMETRAL FORCE

3.19.3 In the case of expander-backed conformable rings, the measuring instrument shall be fitted with a suitable vibratory device for minimizing effects of friction.

3.20 *Flatness of Side Flanks in Radial Direction* ( $T_w$ )

3.20.1 Radial deviation of upper side face relative to the datum surface in the axial section are of two types:

a) Decreasing from outside to inside, positive ( +ve ); and

b) Increasing from outside to inside, negative ( −ve ).

**3.20.2** Flatness of side flanks shall be measured with radially moving dial indicator ( having least count of 0·001 mm ) at the centre between the load distribution points outlined. The ring shall be loaded radially at both sides of the gap 90° on each side of the gap and at 180° from the gap with the following forces:

| | |
|---|---|
| For nominal diameter up to 125 mm | 2·5 N/Point |
| For nominal diameter above 125 mm up to 175 mm | 4 N/Point |
| For nominal diameter above 175 mm up to 200 mm | 5 N/Point |

The maximum of the four measured values shall be taken as the deviation for the flatness ( Fig. 23 ).

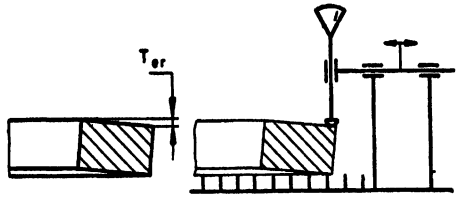



FIG. 23 MEASUREMENT OF FLATNESS OF SIDE FLANKS

**3.21** *Flatness of Side Faces in Circumferential Direction* ( $T_{cn}$ )

**3.21.1** Circumferential deviation of the upper side-face relative to the datum surface in the circumferential direction.

**3.21.2** Flatness of the side faces shall be measured at the middle of the ring radial thickness between the five load application points as shown in Fig. 24. The difference between the maximum and minimum reading of the dial indicator having least count 0·001 mm is the amount of deviation in flatness.

**3.21.3** The ring flatness shall be measured by allowing the ring to fall freely by its own weight through two polished flat plates with a fixed distance between them. The distance between plates shall be greater than the maximum axial width of the ring by 0·05 mm up to 100 mm diameter and 0·06 mm for above 100 mm diameter.

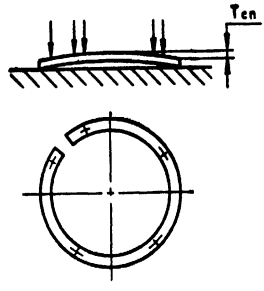



FIG. 24 MEASUREMENT OF FLATNESS OF SIDE FACES

**3.22** *Free Gap* (f)

**3.22.1** Free gap is the distance between the gap ends of the ring while in a free state, measured in the middle of the ring radial thickness, or in case of internal recess rings, measured at the inner edge of the gap ends as in Fig. 25.

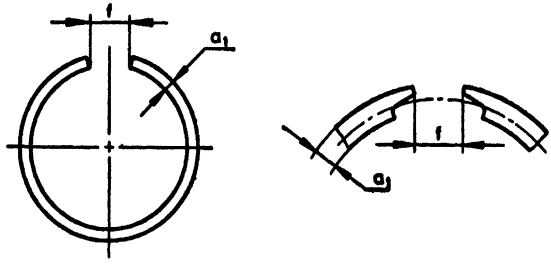



FIG. 25 MEASUREMENT OF FREE GAP

**3.22.2** Free gap shall be measured in a free state, without disturbing it, using a vernier caliper.

**3.23** ***Surface Roughness***

**3.23.1** Surface roughness is the quality of finish of ring faces ( flanks or running face ).

**3.23.2** Surface roughness shall be measured with a special roughness checking stylus instrument with points of 0·5 μm ±0·2 μm. The average of three readings uniformly distributed over the circumference is valid ( Fig. 26 ) for assessment. ( *See* IS : 3073 - 1967 Assessment of surface roughness. )

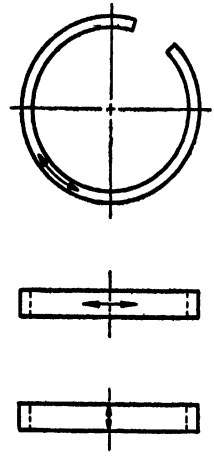


FIG. 26 SURFACE ROUGHNESS MEASUREMENT

## EXPLANATORY NOTE

Piston rings control to a large extent, the performance characteristics of IC engines. Taking this aspect into view, the committee dealing with the subject decided to provide a standard for the testing of quality characteristics of piston rings. The criterion while formulating this Indian standard has not been to detail the individual characteristics of the various types of piston rings but to recommend a measuring system for the dimensional and load characteristics of the rings.

The systems outlined in this standard are aimed at measuring the parameters of rings given in IS : 5791-1986 and IS : 8422 ( Parts 1 to 8 ) covering the dimensions and loads for various types of rings.

While preparing this standard, assistance has also been derived from the following:

DIN 70907-1980 — Piston rings — Test of quality characteristics, terms and measuring principles

BS 5341 ( Part 4 ) : 1976 — Piston rings up to 200 mm diameter for Reciprocating Internal Combustion engines — Part 4 — Measuring and testing procedures.



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